

AEROSOL SIZE DISTRIBUTION: What How and Why

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What is it

How is it shaped

Why is it important

How will we measure it during MODIS

AEROSOL SIZE DISTRIBUTION

What is it (examples)

- Sulfate particles formed in the atmosphere from oxidation of SO_2 in the air ($r: 0.001\text{-}0.03 \mu\text{m}$) or inside cloud drops ($0.1\text{-}0.3 \mu\text{m}$).
- Organic particles from oxidation of organic gases ($r: 0.001\text{-}0.03 \mu\text{m}$)
- Black Carbon - absorbing particles from car emission and biomass burning
- Smoke particles formed from condensation of organic unburned gases on solid particles (ash or black carbon) ($0.03\text{-}0.3 \mu\text{m}$).
- Dust particles from soils and rock erosion ($1\text{-}3 \mu\text{m}$).
- Maritime salt particles ($0.8\text{-}1.5 \mu\text{m}$).
- Stratospheric sulfate particles ($\sim 0.5 \mu\text{m}$).

AEROSOL SIZE DISTRIBUTION

How is it shaped

- Production
- Coagulation, absorption of small particles by larger
- Cloud processes
- Effect of humidity
- Deposition, rain out

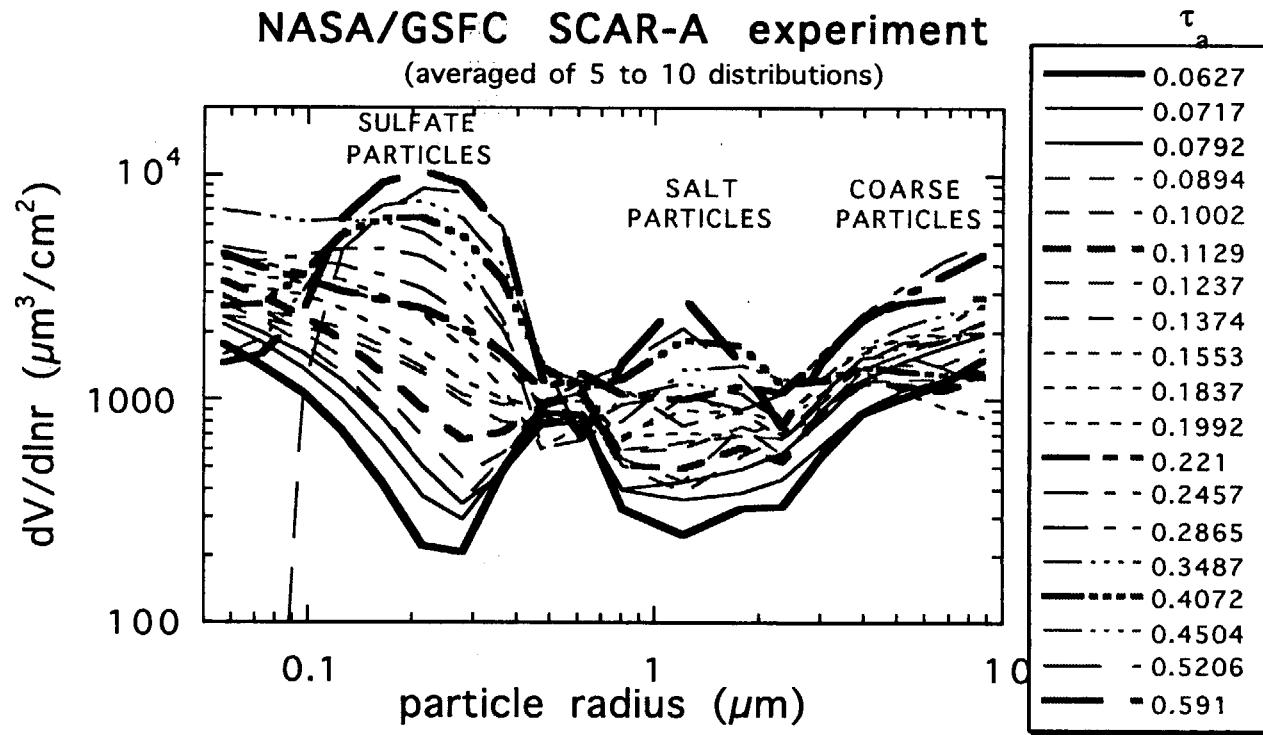
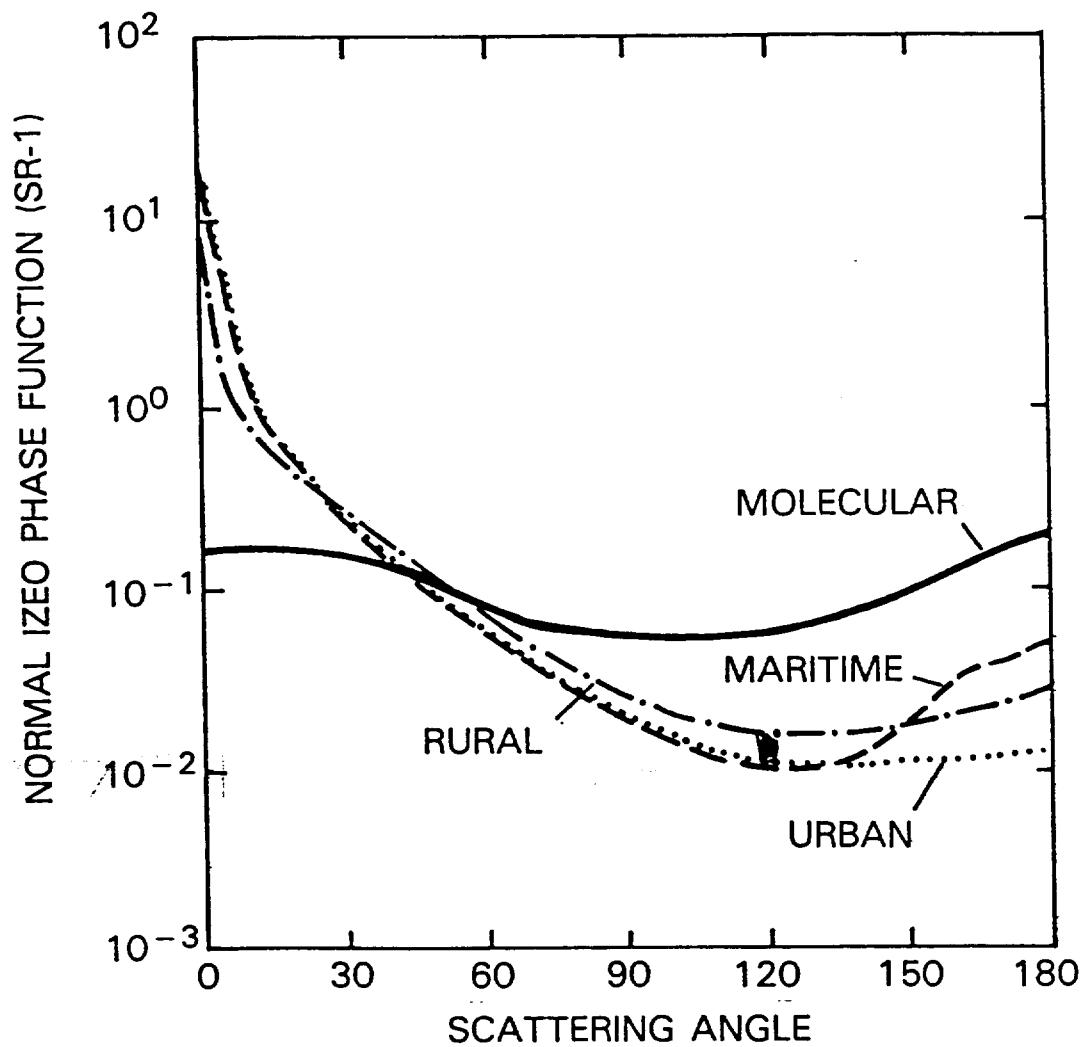


Fig. 1: Aerosol volume distribution derived from sky measurements by sun/sky radiometers during the SCAR-A (Smoke, Clouds And Radiation - Atlantic) experiment. Data are sorted as a function of the optical thickness, τ_a , and averaged every 10 or 5 measurements. For radius $r < 0.3 \mu\text{m}$ - accumulation mode; $0.3 < r < 0.8 \mu\text{m}$ - stratospheric aerosol; $0.8 \mu\text{m} < r < 2.5 \mu\text{m}$ - maritime salt particles; $3 \mu\text{m} < r$ - coarse particles.

AEROSOL SIZE DISTRIBUTION

Why is it important

- Determines the magnitude of aerosol radiative forcing
 - convection, climate cooling
- CCNs - cloud microphysics, cloud fraction, precipitation, climate
- Surfaces for atmospheric chemical reactions (ozone hole)
- Effect on remote sensing of land and ocean (atmos. corrections)



16-2

FIG-2

SIZE DISTRIBUTION

$$\frac{dn}{dr} = \frac{N_0}{\ln(10) \cdot r \cdot \sigma \sqrt{2\pi}} \exp \left| \frac{(\log r - \log r_0)^2}{2\sigma^2} \right|$$

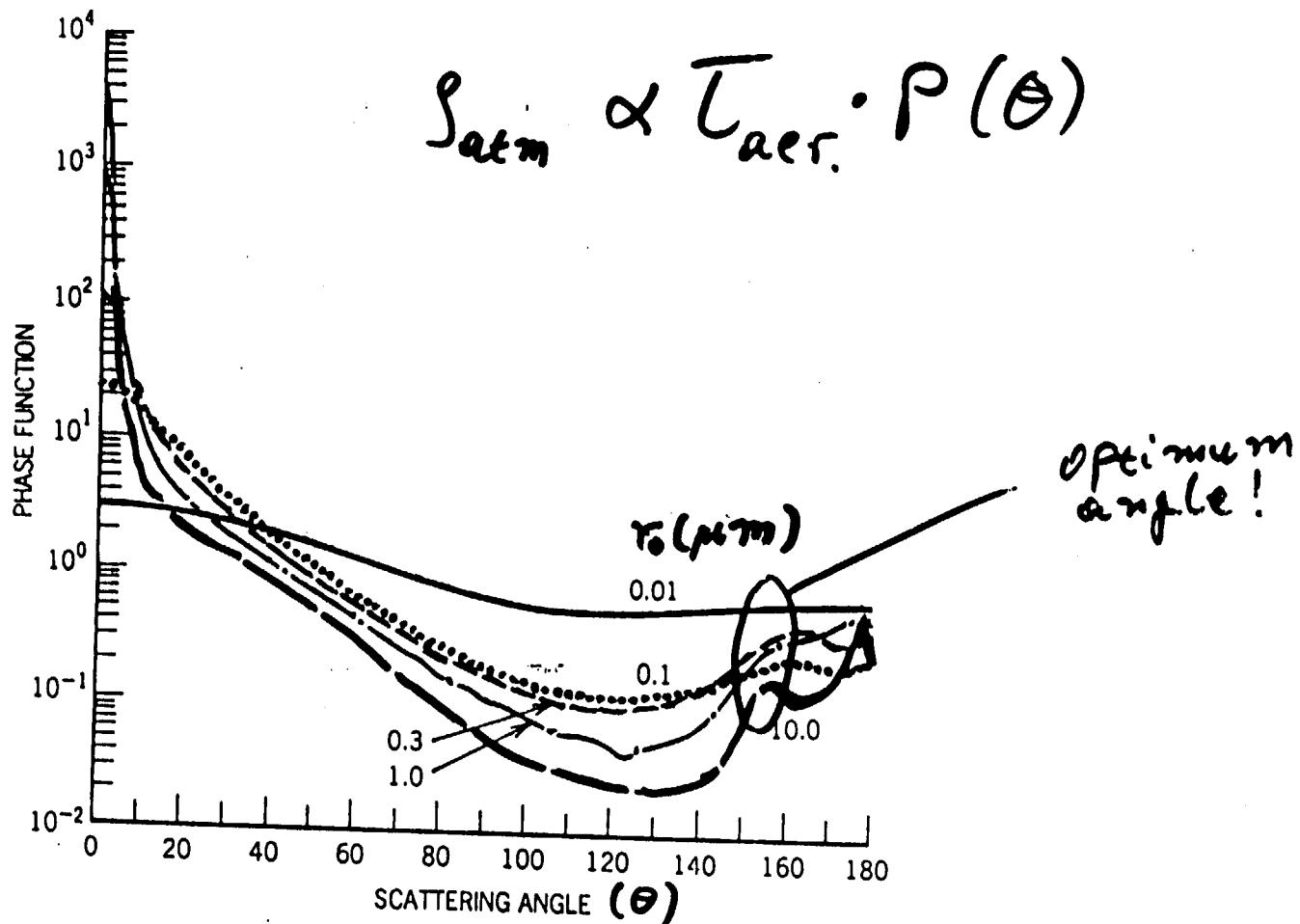
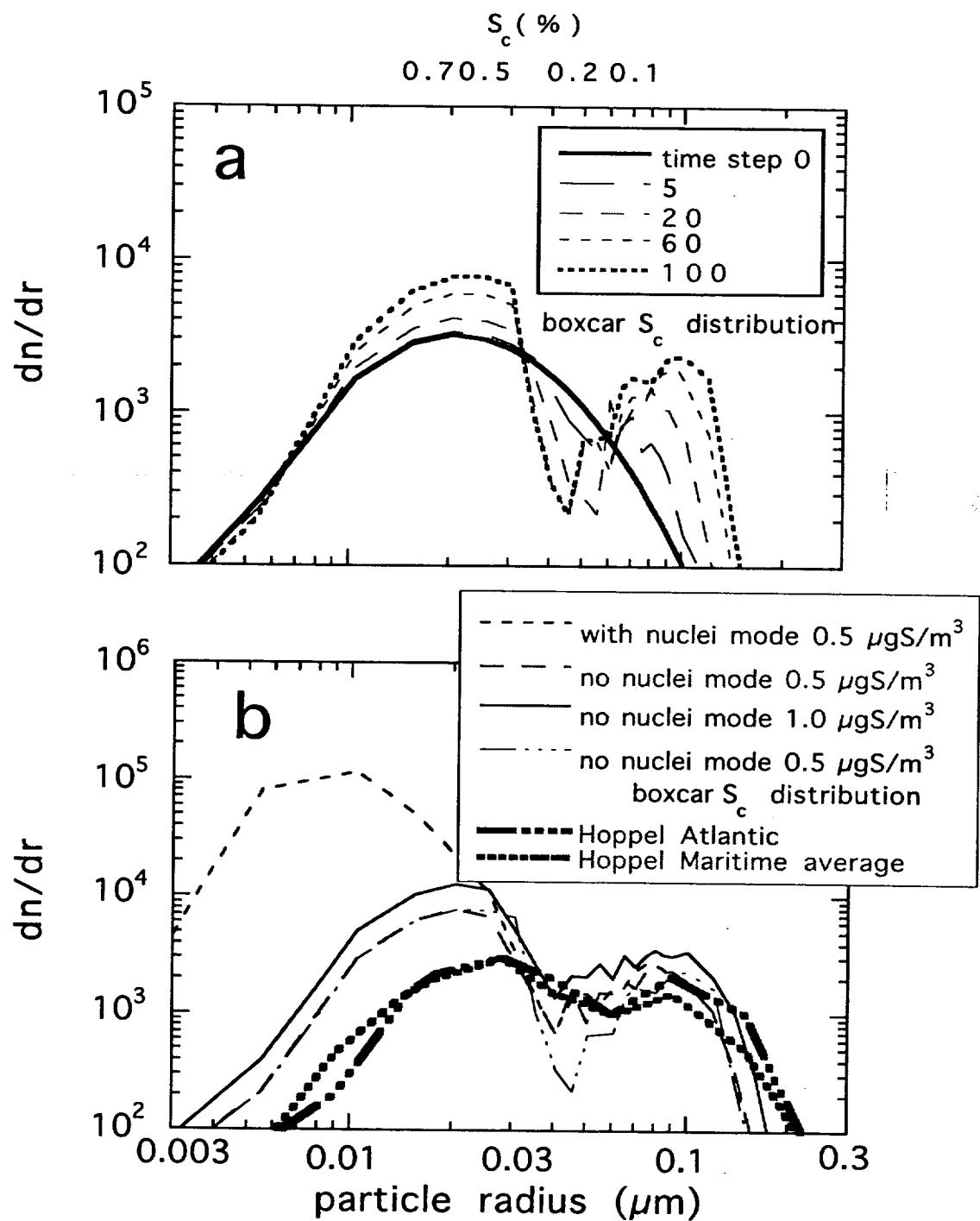
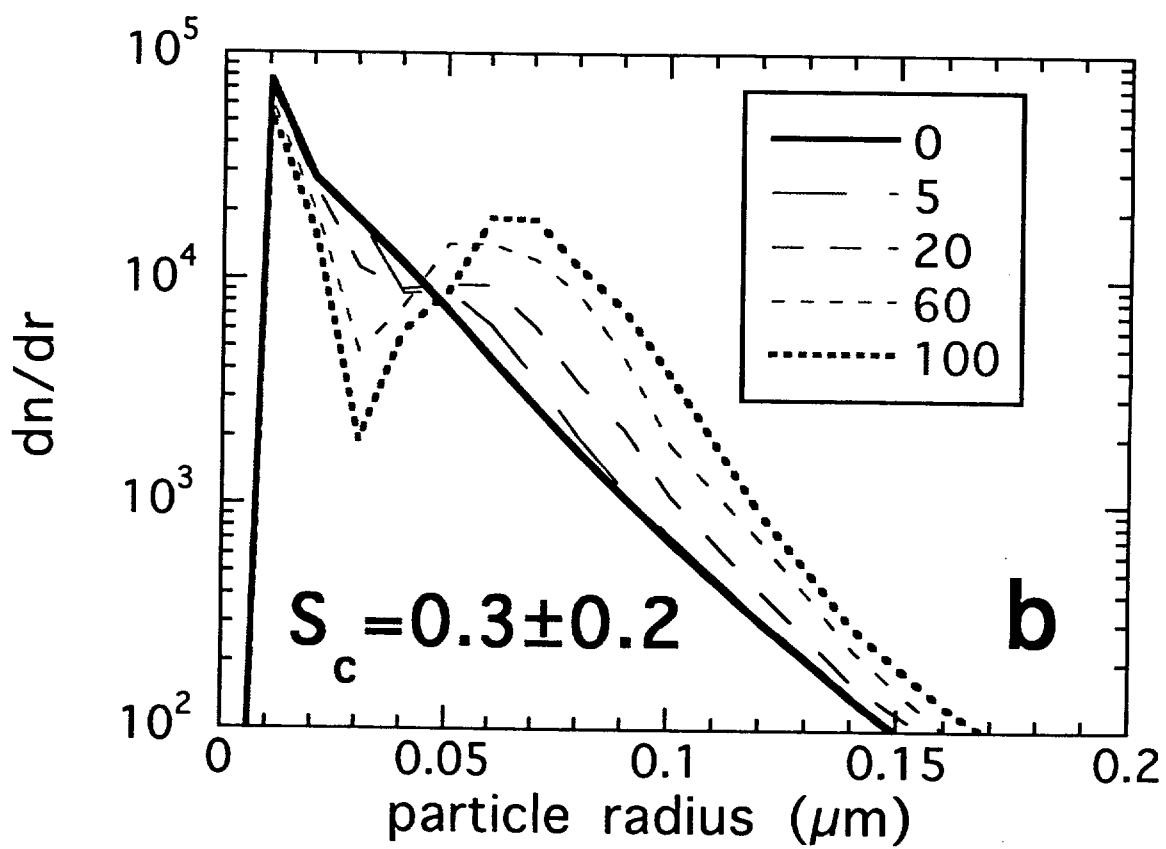
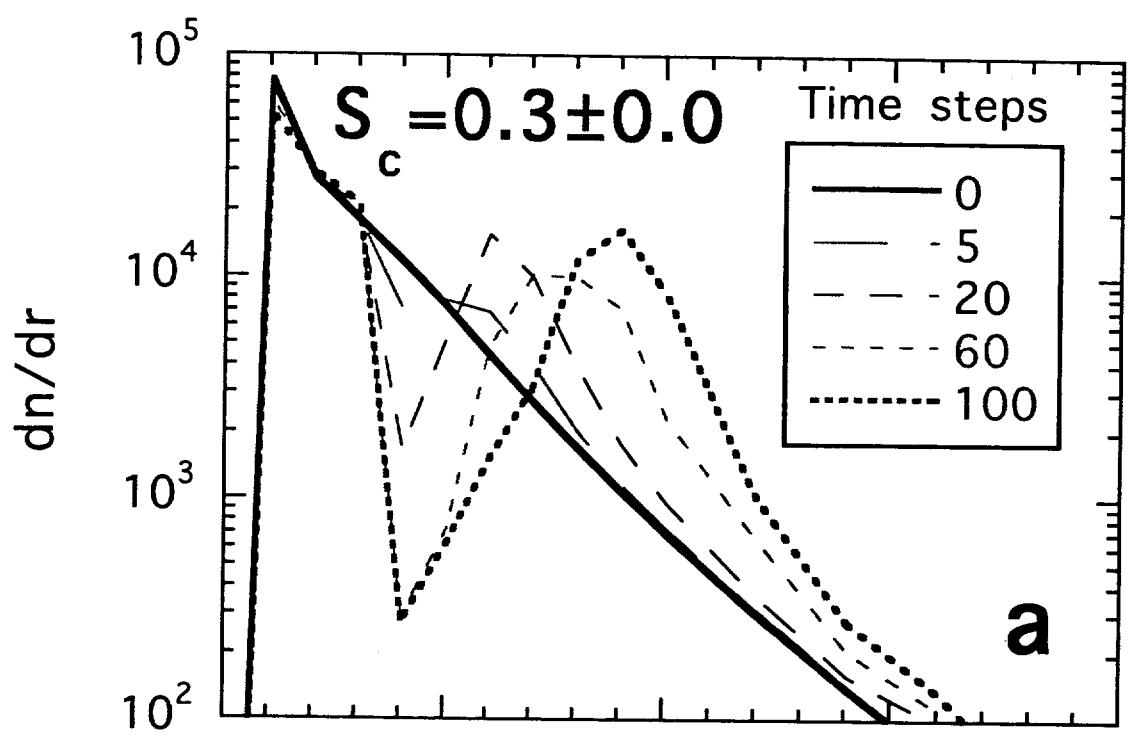
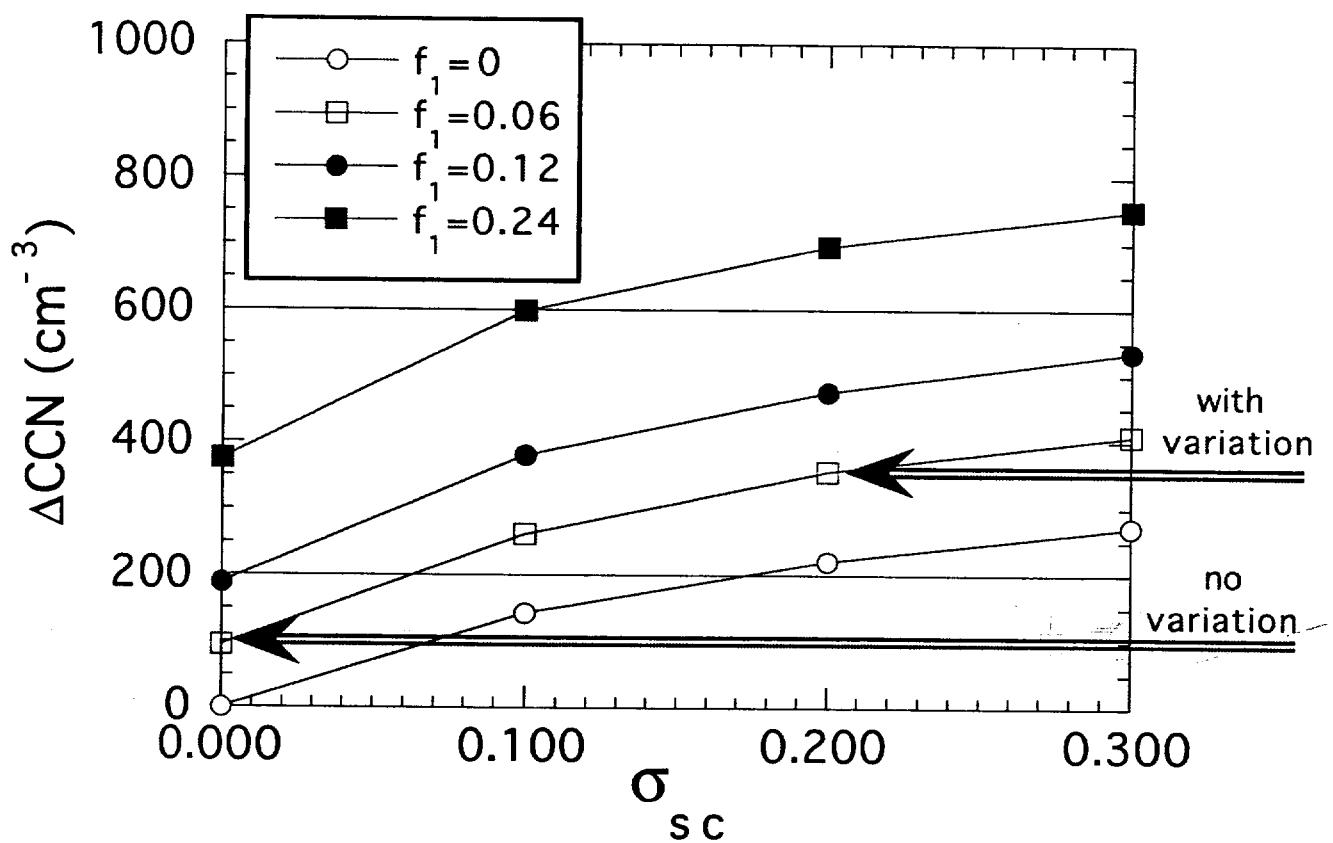


Figure 5 The aerosol scattering phase function for a log-normal size distribution ($\sigma = 0.4$) and several values of r_0 (μm -indicated for each curve).

Kaufman, 1989







AEROSOL SIZE DISTRIBUTION

How will we measure it during MODIS

Over ocean	Over land
<p>MODIS: Derive the aerosol size distribution from the spectral dependence of the radiance (0.55-2.1...3.9 μm).</p> <p>-----</p> <p>GROUND: Validate using ground based remote sensing with sun/sky radiometers.</p>	<p>MODIS: Derive the aerosol optical thickness using radiance in the blue and red for predetermined dark pixels.</p> <p>-----</p> <p>GROUND: Use ground based remote sensing with sun/sky radiometers to measure the size distribution ==> derive regional aerosol models ==> use in MODIS remote sensing.</p>

MODIS and Cimel --
One System For Land Observations

C. D. Miller, University of Colorado

MODIS

global coverage

1-2 obs per day

land aerosol optical
thickness

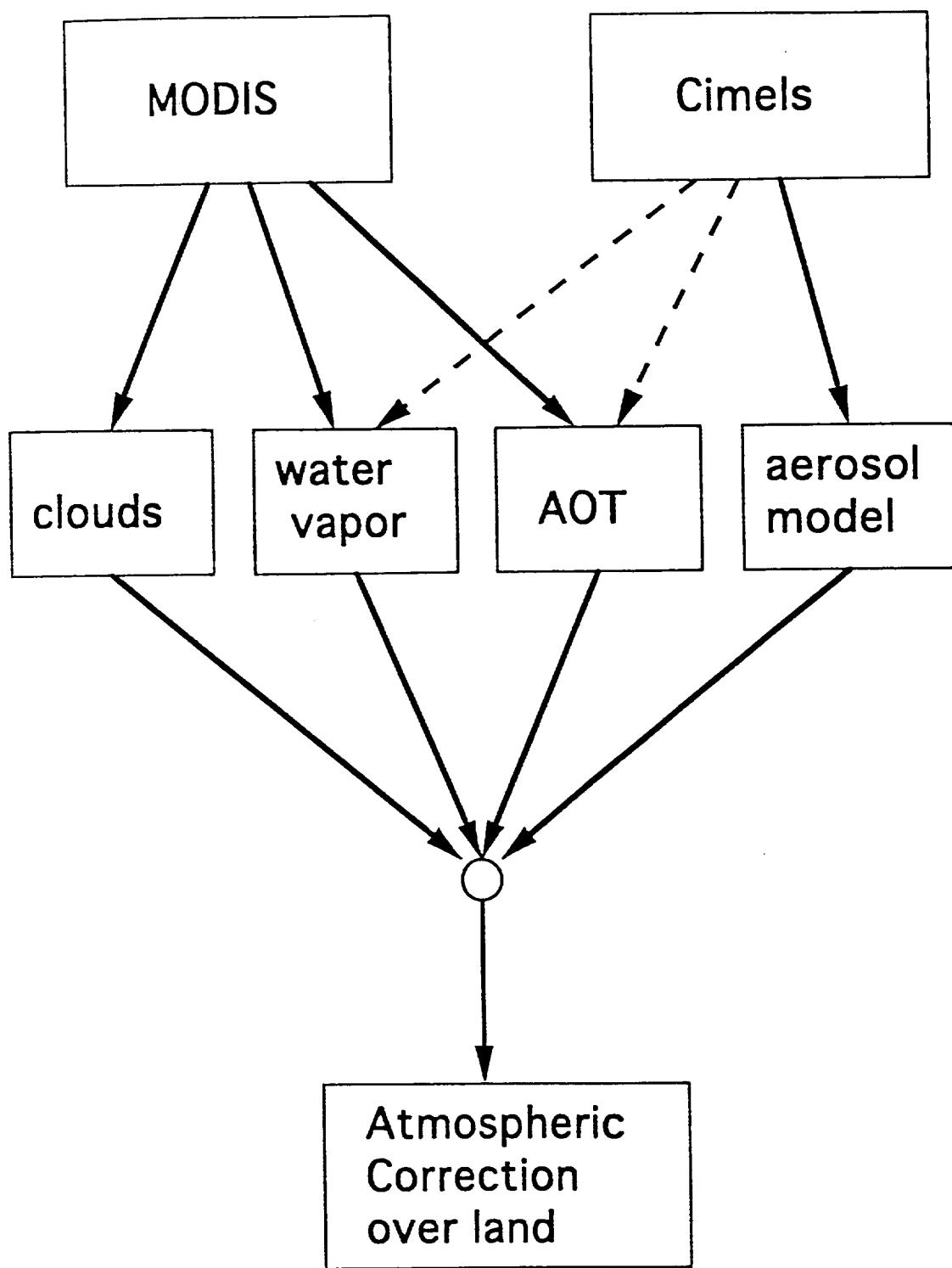
Cimel

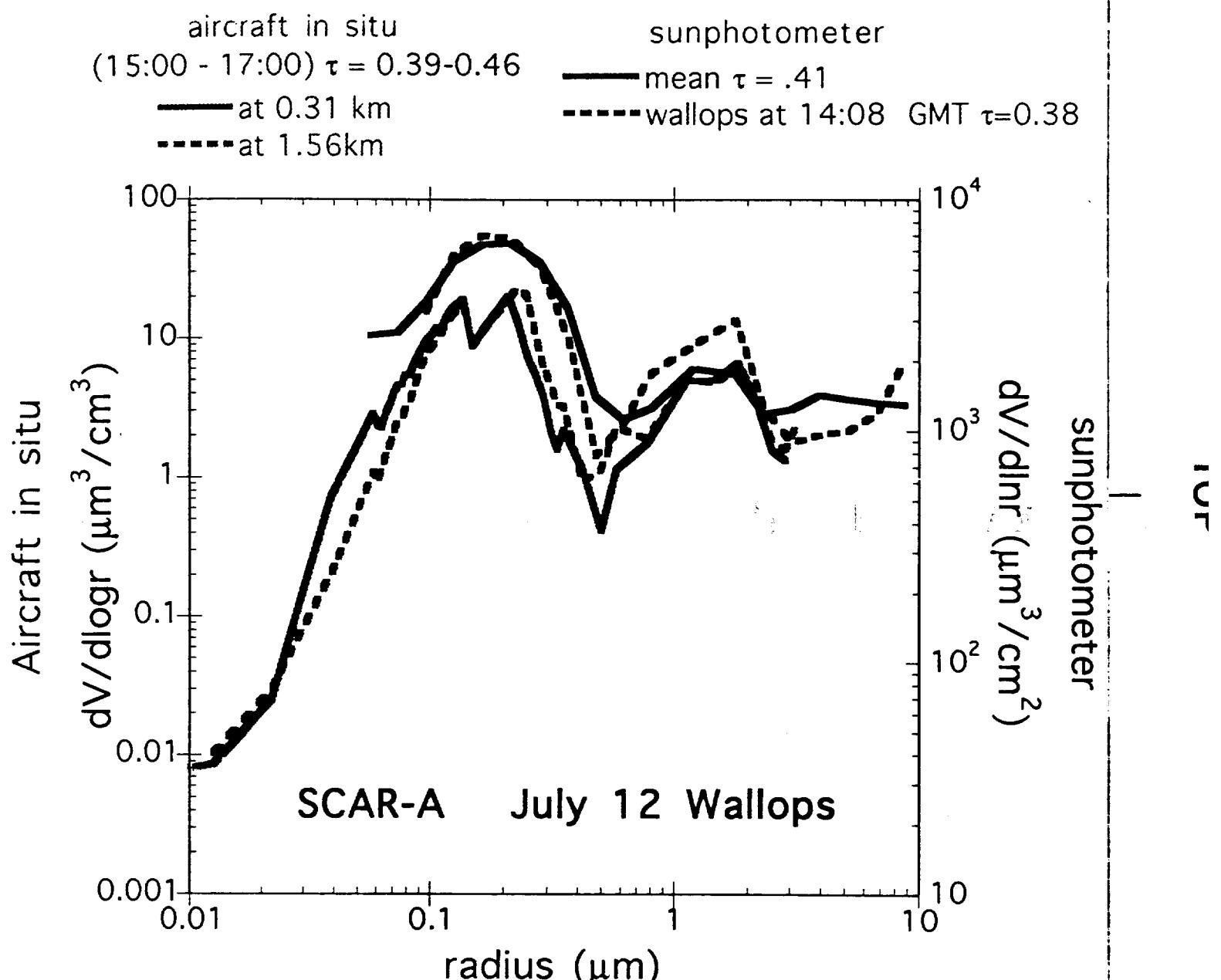
smaller spatial coverage

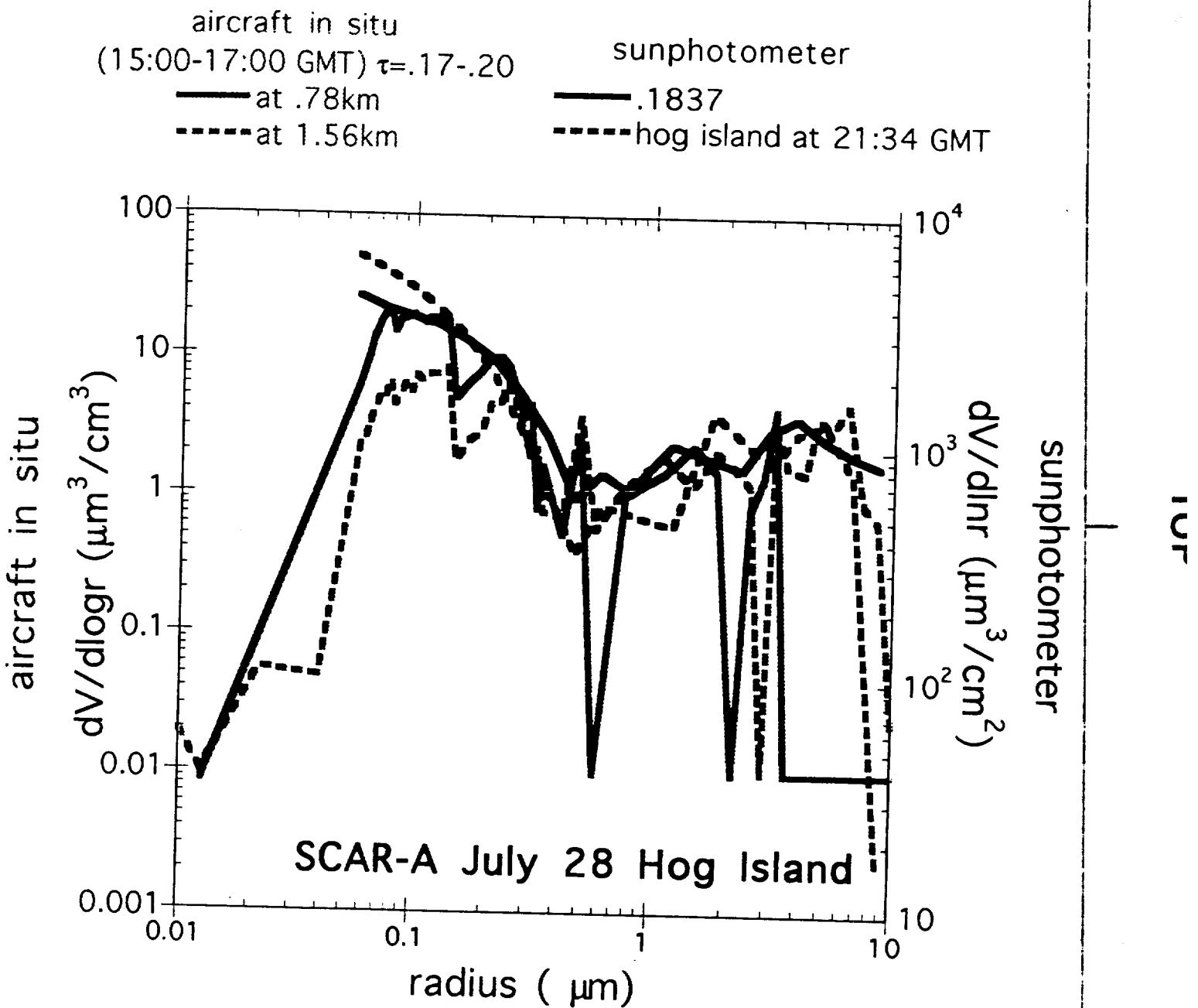
full diurnal coverage

land aerosol size
distribution

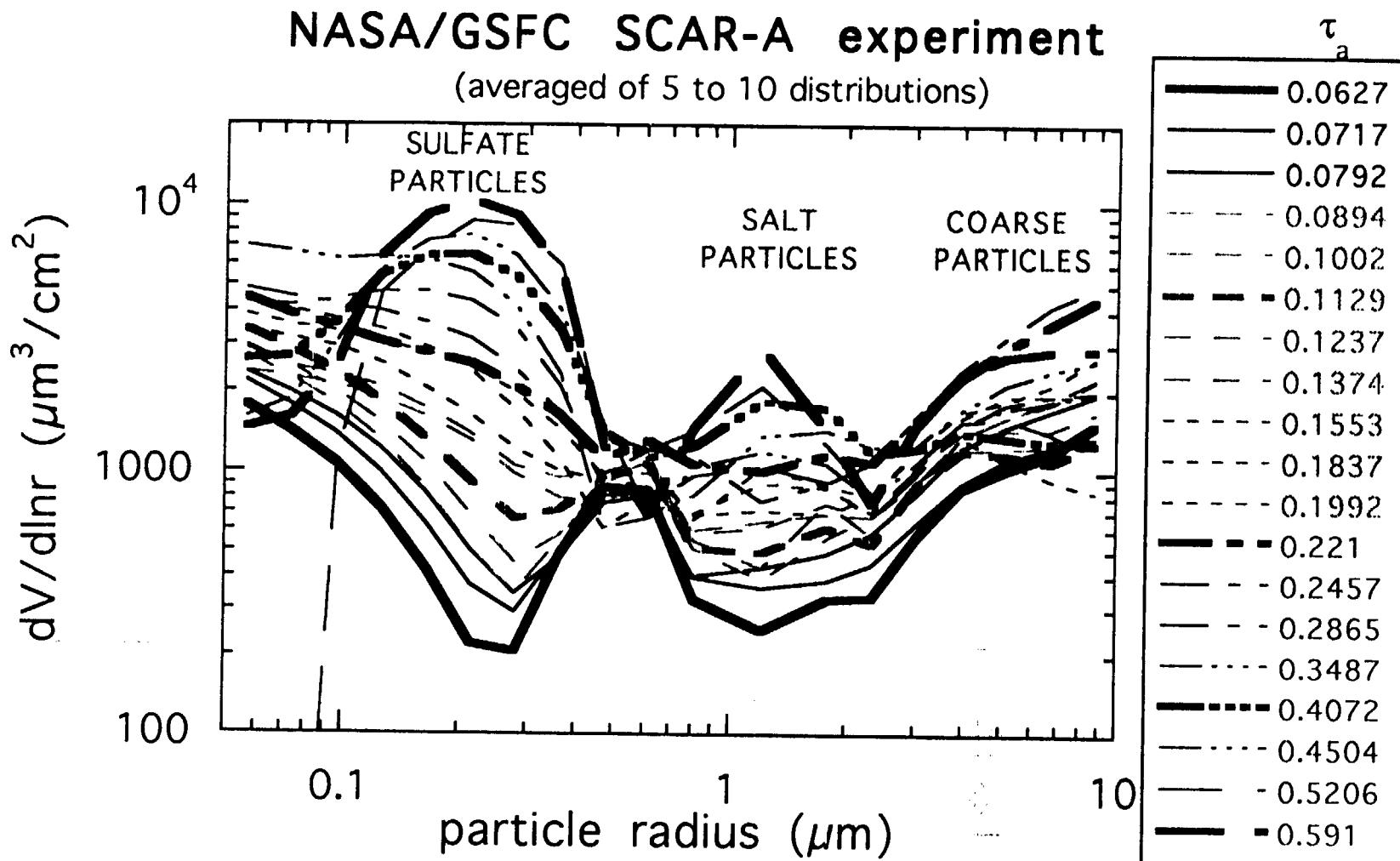
phase function

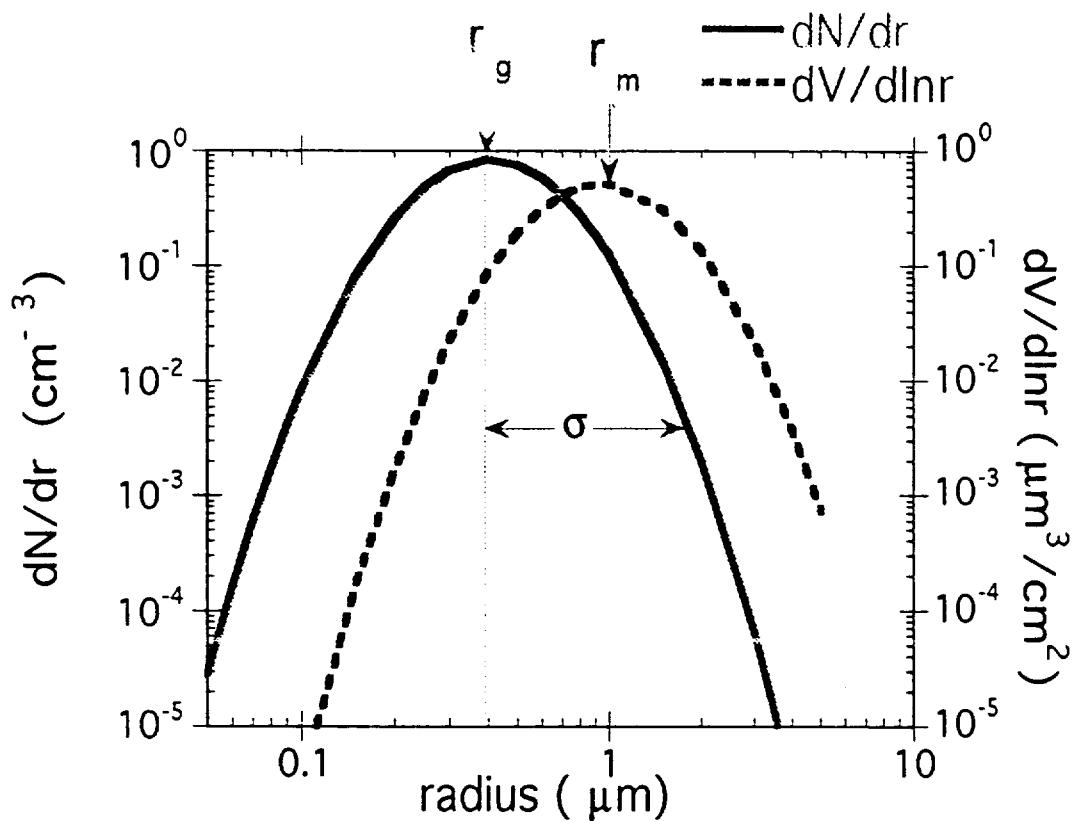






TOP



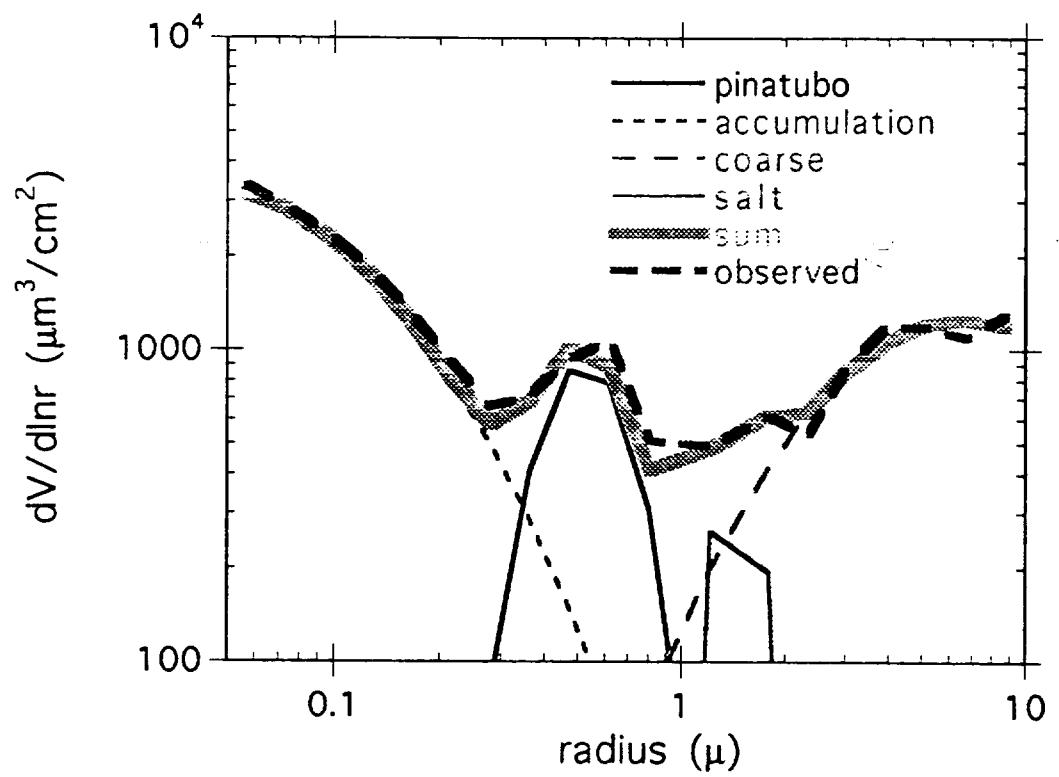


$$\frac{dN}{dr} = \frac{N_0}{\sqrt{2\pi}r\sigma \ln(10)} \exp \left[\frac{-(\log \frac{r}{r_g})^2}{2\sigma^2} \right]$$

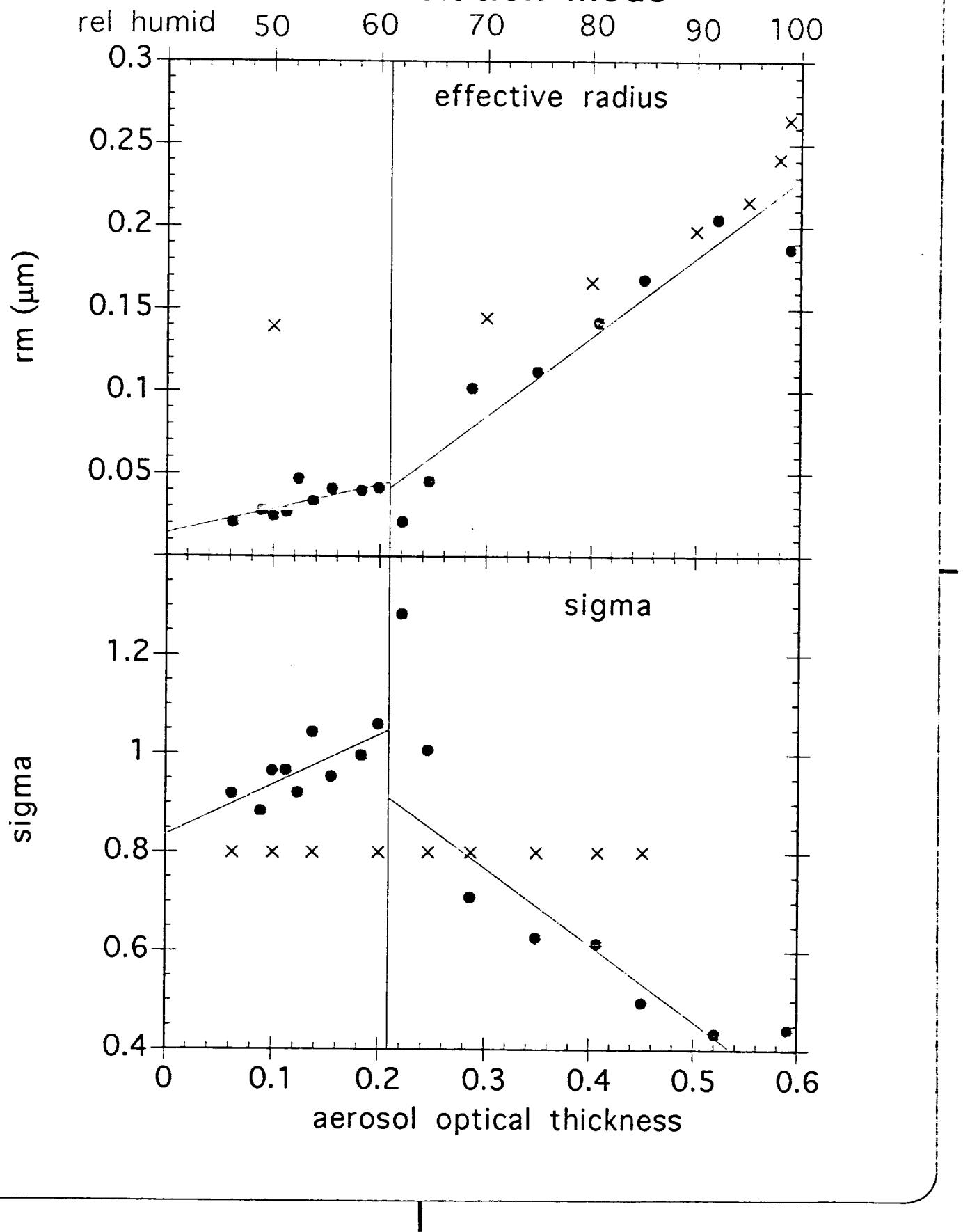
$$\frac{dV}{d\ln r} = \frac{4}{3}\pi r^4 \frac{dN}{dr} = \frac{2}{3} \frac{\sqrt{2\pi} N_0 r^3}{\sigma \ln(10)} \exp \left[\frac{-(\log \frac{r}{r_g})^2}{2\sigma^2} \right]$$

$$r_m = r_g e^{2.5(\sigma \ln(10))^2}$$

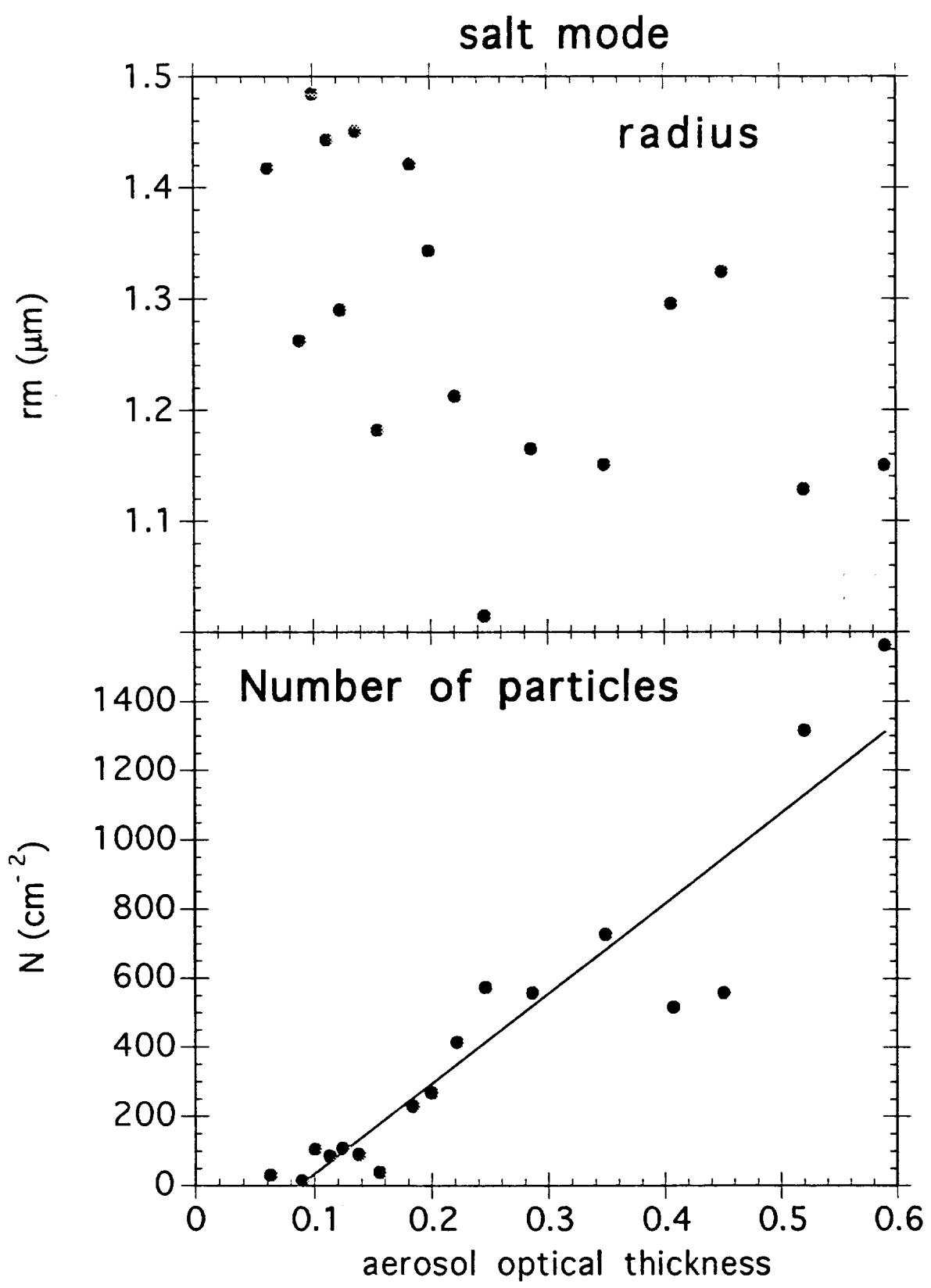
aerosol optical thickness = 0.11

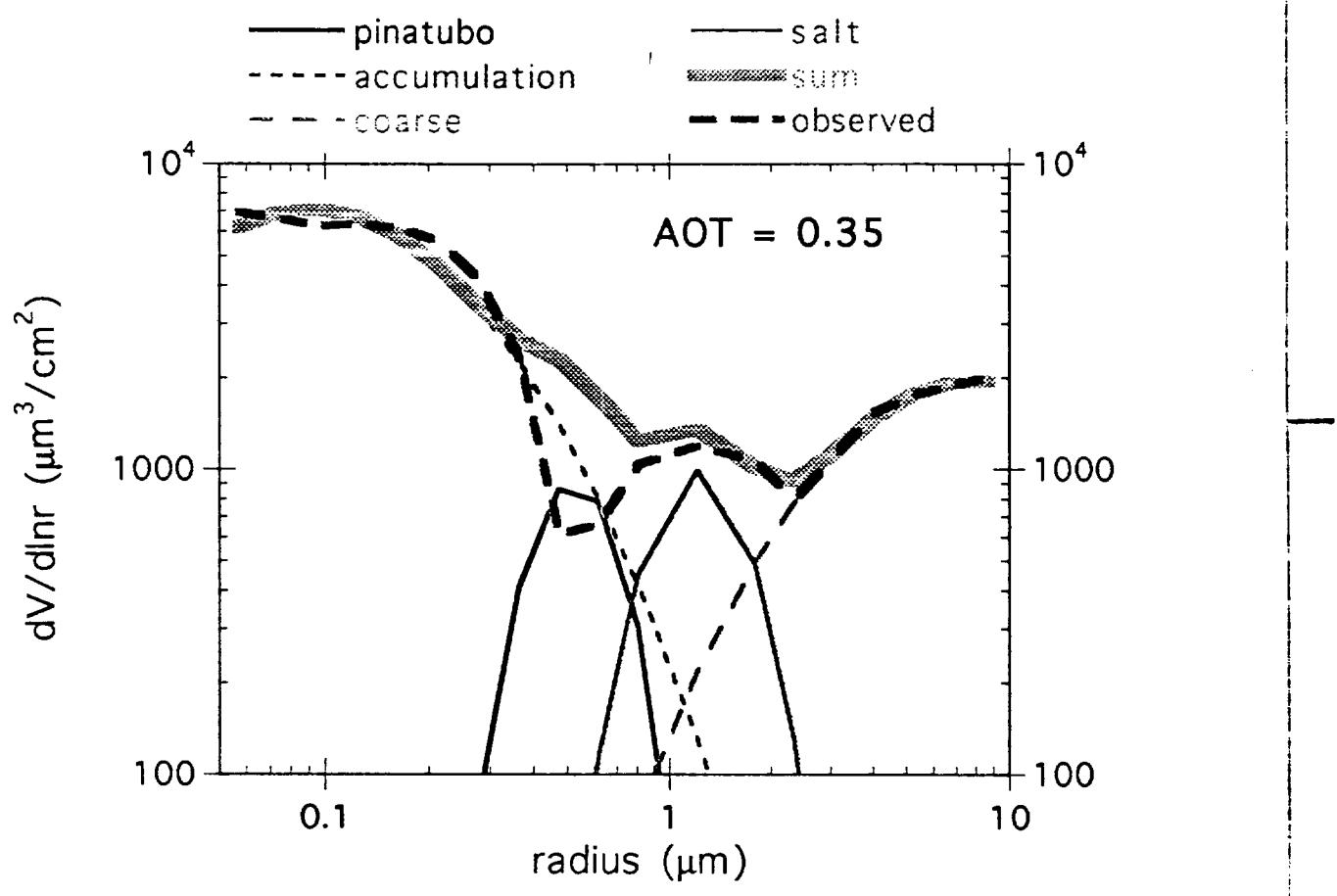


accumulation mode



TOP





Conclusions

Aerosol size distribution is critical for accurately modeling the effect of aerosols on climate.

Need to replace the AFGL models with dynamical models representative of the whole atmosphere.

Ocean -- MODIS provides all aerosol characteristics.

Land -- Need combined system of MODIS and ground instrumentation to provide aerosol as a function of space, time and size distribution.